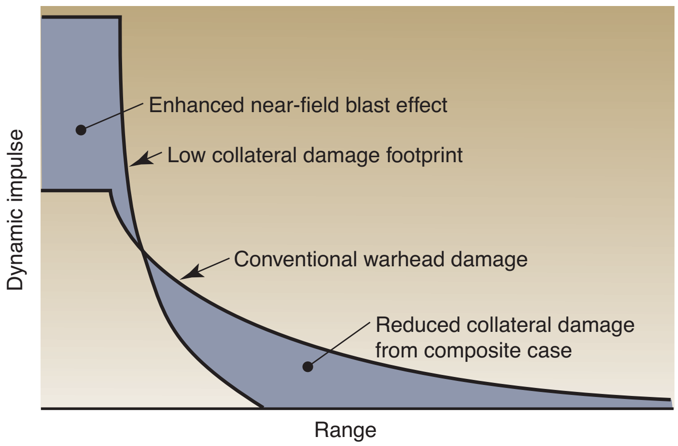
# A New Generation of Munitions

AS the conflict in Iraq unfolded this spring, the world watched in amazement at the accuracy of the latest generation of precision-guided missiles. These weapons allowed U.S. and allied air forces to operate unconstrained by the limits of daylight, and they came to “rule the night.” Now, the U.S. armed forces want to further extend this weapon capability by developing armament that will reduce collateral damage—that is, reduce destruction outside the radius of an intended target—while enhancing its destructive force on the target.

To achieve this goal, explosives and composites experts at Lawrence Livermore are leading an effort under a memorandum of understanding (MOU) between the Department of Energy and the Department of Defense that was formalized in 1985. The MOU established a joint munitions program that takes advantage of the Laboratory’s expertise in high explosives, computer simulation, and other technologies. In the present effort, a Livermore team led by engineer Michael Murphy is working in partnership with the Air Force Research Laboratory at Eglin Air Force Base in Florida and the Naval Surface Warfare Center in Dahlgren, Virginia. The team is developing munitions with carbon-composite casings filled with new formulations of a high explosive that will greatly reduce damage to objects beyond the intended target.




The new munition is designed with an enhanced-blast explosive, which increases the impulse delivered to the intended target, and a carbon-fiber composite case, which eliminates collateral damage caused by case fragments. The graph shows that even though the new munition produces a more powerful blast, the range of its damage footprint is smaller than that of conventional warheads.

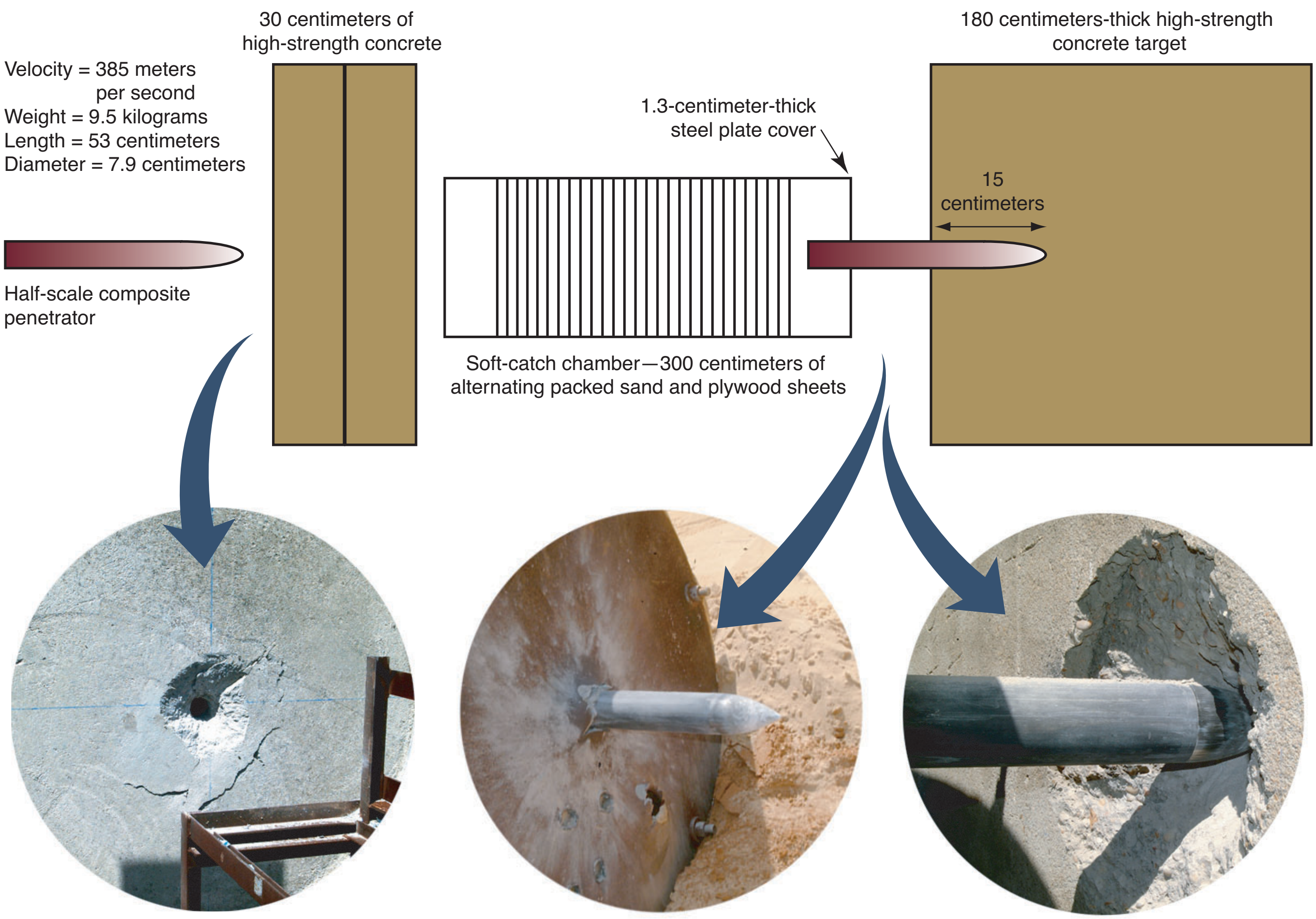
Livermore researchers have studied high explosives for decades as part of their work in designing nuclear weapons. The Laboratory is the first to design a carbon-composite cased munition with an enhanced-blast-formulation explosive. “Much of the weight in today’s munitions is in the steel casing,” explains Murphy. “The heavy steel case, coupled with a high explosive, can penetrate hard targets such as reinforced concrete bunkers. However, the blast created by conventional steel-cased munitions can send shrapnel to distances of more than 1 kilometer from the target. This puts civilians and friendly forces at risk. We’re trying to change that by developing carbon-cased munitions with penetration capability.”

The challenge for the Livermore team was to design a munition that could penetrate hard targets as deeply as a steel-cased munition while restraining the energy of the blast within a small radius. Murphy notes, “If you could get the job done without throwing all that steel around, you would reduce collateral damage. It is a matter of controlling the energy and putting it to better use.” Carbon composite is lightweight, and the weight of the carbon-composite case will account for only 10 to 20 percent of a munition’s total weight. The Livermore team working on the composite-case design and fabrication technology is led by engineer Scott Groves.

The first question facing the researchers was whether a composite case could penetrate concrete as deeply as its steel counterpart. In experiments conducted by Don Cunard at Eglin, Groves's team demonstrated that it could. The steel-nosed composite penetrator used in the experiments is a half-scale construction of the one used by the military. Shot at a velocity of 494 meters per second, it reached a penetration depth of 48 centimeters, far exceeding the penetration goal of 15 centimeters. In another test (see figure below), a penetrator traveled through 30 centimeters of concrete, 300 centimeters of sand and plywood, a 1.3-centimeter-thick steel cover plate, and another 15 centimeters of concrete, for a total distance of 3.3 meters. One advantage of the composite case, Groves surmises, is that it may be more slippery than steel, which results in less friction against concrete.

## Balancing Destruction and Safety

To enhance the energy delivered to a target while also controlling the radius of the damage area, Livermore researchers Randy Simpson, Mark Hoffman, Roz Swansiger, Wardell Black, Rob Schmidt, and A. J. Boegel are formulating and testing a triamino-trinitrobenzene- (TATB-) enhanced explosive. TATB has long been used at Livermore because it is a powerful explosive that is also very insensitive; that is, it is highly unlikely to explode accidentally. At the same time, the Air Force is developing an enhanced-blast explosive with




Experiments conducted at half-scale demonstrate the ability of the carbon-fiber-cased projectile to survive the penetration through a target consisting of high-strength concrete, packed sand and wood, and steel. The lower part of the figure shows that the projectile survived intact while penetrating through the multilayer target. It penetrated deeper than expected and was not stopped by the soft-catch chamber of sand and wood.

cyclotetramethylene-tetranitramine (HMX). HMX delivers more energy than TATB, but it is also far more sensitive. "It's a tradeoff between safety and energy," says Murphy. "Weapons need to be powerful enough to do the job but safe enough so they are not vulnerable to accidents during transportation."

## Testing the Enhanced Formulas

To test the new TATB-enhanced formulation, researchers conducted static detonation experiments to measure the radius of the blast created. The goal was to deliver the most damage at close range, while leaving objects at a distance intact. In one test conducted at the Air Force Research Laboratory, insulating foam bundles were placed at distances of 2 meters, 3 meters, and 5 meters from the charge as a method of collecting the resulting case fragments. The foam bundle at the 2-meter range was obliterated while the foam bundles at the 3- and 5-meter distances had no case fragment penetrations and thus were unscathed. The few carbon case fragments that were recovered at the 2-meter range measured less than 1 centimeter each; no fragments were recovered beyond this distance. The Livermore team and its Air Force and Navy partners are strongly encouraged by the results.

The explosive fill in the munitions is fabricated from a mixture that has the consistency of toothpaste. The mixture is cast into the carbon-fiber case and cured. This process allows the munitions to be created in a variety of shapes for use in many different applications. The munitions created with the new technology will look and feel the same as those in use today, so they can be used with existing weapons. Aerojet, the company that builds the rocket boosters for the U.S. space program, is fabricating the composite munition case.

Murphy, along with Livermore researchers Estelle McGuire and Jack Reaugh, is also conducting simulations of the target penetration and detonation experiments to predict the warhead's physical and timing parameters, such as velocity, pressure, and energy delivery. The simulations are performed using DYNA2D, CALE, ALE3D, and CHEETAH, computer simulation programs developed at Livermore. The results produced by these simulations reflect differences in timing and behavior between conventional steel-cased, high-explosive munitions used today and the unique design of the carbon-composite casing with the enhanced-blast explosive.

## Creating Tailored Warheads

Murphy believes that with adequate funding, the new composite-cased TATB-enhanced-blast munitions can be ready in six months to a year. The Livermore team is developing munitions for a few specific applications that have been requested by the Air Force. These munitions can easily be tailored to other applications as well. "If we develop something that looks interesting, someone will provide the funding for us to make it. Because of recent military activities in Iraq and Afghanistan, some of our armament resources are depleted and have to be replenished. Now is a good time to bring in the newer technology," says Murphy.

One of the current goals of military operations is achieved through the ability of U.S. armed forces to reliably hit and destroy their targets while minimizing collateral damage. In addition to providing more safety to soldiers and civilians on the ground, the new, low collateral damage munitions will also minimize the rebuilding that is needed after a war. The Air Force–Navy–Livermore team is excited about these promising advancements that will bring low collateral damage munitions to the next generation of armament technology.

*—Gabriele Rennie*

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